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Solar Programs Office

INTHOL COMPUTER PROGRAM MANUAL FOR NONLINEAR COLLECTORS

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SOLAR PROGRAMS OFFICE

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1.0 INTRODUCTION

The accurate modelling of solar collection devices other than the conventional "flat-plate" type collector has been inhibited by the widespread acceptance of the Hottel-Whillier linear collection efficiency model. For years the Canadian solar community, especially manufacturers of evacuated tubular collectors, have recognized the need for models that more accurately characterize the performance of solar collection devices. A model has been required that characterizes flat-plate collectors as well as nonlinear devices, allowing the relative performance and cost-effectiveness to be compared.

This manual describes a nonlinear solar collector model and the difference from linear computer programs. The collector model itself is a quadratic of the inlet-to-ambient temperature difference. The simulation method of the nonlinear model uses iterative calculations rather than the simultaneous solution of the various linearized component models that make up a system.

The new program has been named NONLIN. The Solar Programs Office has installed the program on the mainframe computer at Control Data for user access.

A tutorial session describing the weather and data files and containing sample NONLIN simulation runs is included.

2.0 MODEL DESCRIPTION

This section describes the models used in both the linear and nonlinear programs.

2.1 The Existing Linear Simulation Method

This Section is intended to introduce the reader unfamiliar with the internal operation of linear programs to the basic models and simulation method. It has been included only to allow a more in-depth understanding of the changes that have been required when the nonlinear collector model was added to the linear program. For a more detailed treatment of NONLIN operation consult the User Manual (ref. 2).

2.1.1 The Collector Model

The familiar Hottel-Whillier linear solar collector performance model is used in the WATSUN program:

$$QC = F_R\tau\alpha \; K \; I - F_R U_L \; \Delta T \qquad (W/m^2) \qquad (1)$$

where

QC	= power collected	(W/m^2)	
$F_R\tau\alpha$	= collector heat removal/optical efficiency		
I	= incident solar radiation	(W/m^2)	
K	= the incident angle modifier		
$F_R U_L$	= collector heat loss factor	$(W/m^2.°C)$	
ΔT	= inlet to ambient temperature difference	(°C)	
	= TCI - Ta	(°C)	(2)
TCI	= collector fluid inlet temperature	(°C)	
Ta	= ambient temperature	(°C)	

In this model, all collector heat loss is assumed to be linear with the collector to ambient temperature difference (ΔT) and is lumped into the F_rU_L term. However, heat loss in a solar collector is composed of three distinct elements: conductive, convective and radiative energy. The first of these is basically linear with ΔT, the second is close to being linear with ΔT (usually a 1.25 or 1.33 power), and the third, radiation, depends on the difference between the fourth powers of temperature.

2.1.2 Heat Exchangers

Three types of heat exchangers are modelled: a constant- effectiveness external version, an immersed-coil-in-tank version and a wrap- around-tank version. External exchangers with an effectiveness of one (1.0) are not represented.

Due to the presence of the preheat storage tank, a heat exchanger placed on the load side of the storage tank does not directly affect the instantaneous performance of the collector array (storage tank temperature is assumed to be constant within the hour). As a result, program developments were required only for collector - side heat exchangers when the nonlinear collector model was added. The manner in which linear models handle load-side heat exchangers did not need to be altered.

The equations cited below apply to collector - side heat exchangers only. They were obtained by referring to ref. 2 and the WATSUN 6.0 EXCH routine.

External Counter Flow:

$$EF = (T_{in}-T_{out})/(T_{in}-TSI) \qquad (3)$$

where EF = heat exchanger effectiveness
T_{in} = inlet temperature to heat exchanger (°C)
T_{out} = outlet temperature from heat exchanger (°C)
TSI = preheat storage tank temperature (°C)

Equation (3) has been solved simultaneously with the linear collector model of Equation (1) to yield expressions for TCI and TCO (the collector inlet and outlet temperatures) in the linear simulation program.

Immersed Coil:

$$T_{out}=TSI+[DIA^{**}.75*129.79*LE/MCP+(T_{in}-TSI)^{**}-.25]^{**}-4 \qquad (4)$$

where T_{in} = inlet temperature to heat exchanger (°C)
T_{out} = outlet temperature from heat exchanger (°C)
TSI = preheat storage tank temperature (°C)
DIA = coil outside diameter (m)
LE = coil length (m)
MCP = coil heat capacity flow rate (W/°C)

Present program models uses a linearized version of Equation (4) to allow simultaneous solution of the collector and exchanger equations, thereby allowing the collector inlet and outlet temperatures to be determined. The temperatures of the previous hour are used to set the operating point (fluid properties).

Wrap Around:

$T_{out} = T_{in} - (HC/MCP) * (TW - TS1)$ (°C) (5)

where T_{in} = inlet temperature to heat exchanger (°C)
T_{out} = oulet temperature from heat exchanger (°C)
TS1 = preheat storage tank temperature (°C)
TW = exchanger average wall temperature (°C)
= $(T_{in} + T_{out})/2$ (6)
MCP = exchanger heat capacity flow rate (W/°C)
HC = wrap-around heat transfer coefficient (W/°C)
= 0.0819*AW*[6E10*(TW-TS1)]**0.33 (W/°C) (7)
AW = wrap-around exchanger surface area (m^2)

The wrap-around exchanger equation can be solved simultaneously with the collector equation, resulting in close form expressions for TC1 and TCO (no iterations required). The estimated fluid property function of the heat transfer coefficient is 6.0E10 (water at 60°C).

2.1.3 System Controller

Linear simulation programs models the differential controller in a system with one "ΔT" for both system turn-on and turn-off. The collector stagnation temperature (obtained by setting QC to 0 in equation (1) and solving for TC1 is compared with the storage temperature each hour.

The expression for TC, the stagnation temperature is:

$TC = K F_r\tau\alpha/F_rU_L I + Ta$ (°C) (8)

where TC = collector plate stagnation temperature (°C)
I = incident solar radiation (W/m^2)
$F_r\tau\alpha$, F_rU_L = collector parameters
K = incident angle modifier
Ta = ambient temperature (°C)

If the difference between TC and TS1 exceeds the control ΔT, the program computes QC and lets the solar system run.

2.1.4 Pipe Losses

Linear simulation programs allow inlet and outlet pipe heat loss coefficient (UA values) to be entered. The heat loss from the pipes are assumed to be linear with the pipe-to-ambient temperature difference.

By treating the pipe-collector subsystem as a "modified" collector, the pipe heat losses are lumped into the array performance parameters. Adjusted $F_r\tau\alpha$ and F_rU_L values are computed for this subsystem based on the actual array $F_r\tau\alpha$ and F_rU_L values, and the inlet and outlet pipe heat loss coefficients. This calculation is done once at the beginning of the year.

All computations using the array performance are then based on these modified $F_r\tau\alpha$ and F_rU_L values, automatically accounting for the pipe heat loss.

2.2 The Improved Collector Model

The improved model, which applies to both "linear" and "nonlinear" flat plate collectors is given by:

$$QC = \left[(A+B \cdot \Delta T)\ K\ (I-E)\right] - \left[(C+D \cdot \Delta T)\ \Delta T\right] \quad (W/m^2) \quad (9)$$

where QC = power collected (W/m^2)
I = incident solar radiation (W/m^2)
K = incident angle modifier
DT = inlet to ambient temperature difference (°C)
= TCI - Ta (°C) (10)
TCI = collector fluid inlet temperature (°C)
Ta = ambient temperature (°C)
A, B, C, D, E = collector coefficients
[Units: A:none B:1/°C; C:$W/m^2.°C$; D:$W/m^2.°C^2$; E:W/m^2]

The A coefficient accounts for the temperature-independent optical factor and heat removal efficiency factors of the collector. The B coefficient introduces a temperature-dependent adjustment to the optical and heat removal factors.

The heat loss term "$(C+D \cdot \Delta T)\ \Delta T$" models the heat loss from the collector as a quadratic on the inlet-to-ambient temperature difference. Although no fourth power terms appear, the use of at least a second-order term for heat loss much improves the characterization for the temperature range of interest.

The E coefficient is a term introduced [ref. 1] to account for the threshold effect in some collectors. It implies that the collector does not begin to collect a positive energy until the radiation (I) exceeds a certain value. And then, only energy above this threshold is collectable. For many collectors this term is entered as zero (0). Some boiling-condensing collector designs may require this term to be other than zero for accurate characterization.

The five coefficients, A to E, must be determined before NONLIN is used to simulate the solar system. The best method is to derive the coefficients based on curve-fitting data obtained from multiple irradiance level performance testing at the National Solar Test Facility. The "CURVE" program [ref. 3] is available from the Solar Programs Office and the National Research Council and is used as a general purpose program to assist with the evaluation of these coefficients.

If a linear collector model is to be run with NONLIN, enter the $F_R\tau\alpha$ value as coefficient A, the F_RU_L value as coefficient C, and set B, D, and E to 0.

2.3 The NONLIN Simulation Method

The installation of the new collector model in linear simulation programs required major program changes. Due to linearization, equations do not directly support the nonlinear model without numerous assumptions.

Four issues were identified as essential when the nonlinear model was installed:

1. All heat exchangers in the system had to be accurately modelled.

2. The controller model used could not be comprised of linearizing assumptions (accurate temperature prediction was essential).

3. Pipe losses still had to be accounted for.

4. The computation of collected energy had to be algebraically correct as per equation (9).

An iterative simulation method is used in NONLIN to solve the system energy flow equations. This method requires no assumptions other than those inherent in the component models themselves, and is easily upgraded and understood. The extra runtime over the straight linear simultaneous solution method used in present programs is in the order of 30%.

Heat exchangers on the load side of the storage element are not affected by the change in the collector model. The storage element prevents the heat exchanger performance from instantaneously affecting the collector array performance.

Since a heat exchanger, that is on the collection side of the storage device, separates the storage from the collector array, the values of TCI and TCO are not known at the beginning of the hour. Therefore, the collector performance cannot be determined directly and an iterative method is used.

The iterative method used is best described in reference to the following schematic:

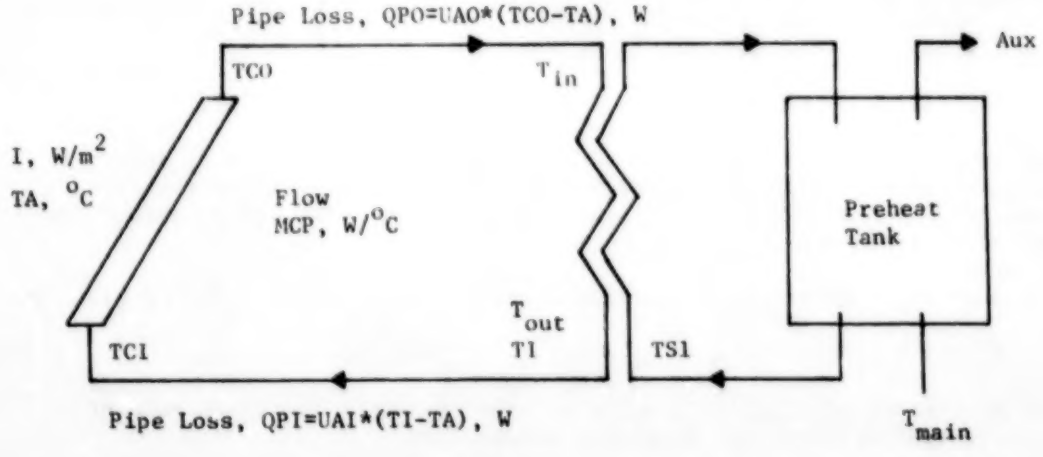

Figure 1: System Schematic

Referring to Figure 1, the iteration method is a follows:

1. Assume TI equals TSI.
2. Compute collectors inlet pipe loss based on T_i, T_a and UA_i.
3. Compute TCI based on T_i, collectors inlet pipe loss and MCP.
4. Compute TCO based on I, T_a, TCI and QC from equation (9).
5. Compute collectors outlet pipe loss based on TCO, T_a and UAO.
6. Compute T_{in} to heat exchanger based on TCO, collectors outlet pipe loss and MCP.
7. Compute T_{out} of the heat exchanger based on T_{in} and exchanger model.
8. If T_{out} is close enough to TI go to 11, if not continue.
9. Adjust TI based on T_{out} and TI(old).
10. Go to 2.
11. Quit.

The iteration continues until TI, the fluid temperature at the beginning of the loop, equals T_{out}, the temperature at the end of the loop.

The Newton-Raphson method has been used to converge on the root (i.e., the TI value). The initial guess of TI is made as the storage temperature, TSI. The loop is then traversed in the direction of flow to determine the remaining temperatures, one at a time. The temperature at the end of the loop, T_{out}, should be equal to TI if the initial guess was correct. If the temperatures are not within the specified tolerance, an adjustment is made to TI and the loop is once again evaluated. From the test runs made only one adjustment is normally required for the temperatures to converge.

The tolerance for convergence has been set at 0.1°C, and the adjustment criteria is given by:

$$TI(new) = TI(old) - f(\Delta TIold) \,/\, f'(\Delta TIold) \qquad (11)$$

where TI(new) = the next value of TI
TI(old) = the last value of TI
f(TI) = the function to be set to 0
= $TI - T_{out}$ (12)
f'(TI) = the derivative of f(TI) evaluated at TI(old).

The equations of all components in the loop, shown in Figure 1, and their derivatives with respect to temperature are required to solve the loop equation. The simultaneous solution of linear or nonlinear equations are solved by iterations.

The derivative of the loop equation (contrast with equation 12) is given as:

$$f'(TI) = df/dTI = 1 - dT_{out}/dTI \qquad (13)$$

The derivative of dT_{out}/dTI can be obtained by using the chain rule of differential calculus on component basis:

$$\frac{dT_{out}}{dTI} = \frac{dTCI}{dTI} * \frac{dTCO}{dTCI} * \frac{dT_{in}}{dTCO} * \frac{dT_{out}}{dT_{in}} \qquad (14)$$

In this manner, each component in the fluid loop must have an input-output equation given for temperature (as a function of all parameters), and the derivative of the component outlet temperature with respect to the inlet temperature.

2.4 The Heat Exchanger Equations

The input-output equations for the heat exchangers and their derivatives are required for the iterative solution. Some adjustements have been made and are mentioned in the text below.

With all the three heat exchanger models, an input-output model can be formulated directly. Given the heat exchanger parameters (e.g., effectiveness for the external, length and diameter for the immersed-coil, or area of the wrap-around heat exchanger), the fluid flow rate, the inlet fluid temperature and the storage temperature, the computation of outlet temperature, and hence performance, can be made directly.

External:

From Equation (3):

$$T_{out} = T_{in} \ (1 - EF) + EF \cdot TS1, \ ^{\circ}C \qquad (15)$$

$$dT_{out}/dT_{in} = 1 - EF \qquad (16)$$

where EF = heat exchanger effectiveness
T_{in} = inlet temperature to the heat exchanger (°C)
T_{out} = outlet temperature of the heat exchanger (°C)
TS1 = preheat storage tank temperature (°C)

Immersed-Coil:

The following equations 18a, 18b and 18c are derived in the same manner as indicated in (ref. 2), by integrating along the length of the coil. The fluid property factors needed for free convection are considered constant. These factors are evaluated for water at 60°C, and linearly changing with the storage temperature. This allows the effect of fluid properties to vary as the storage tank warms and cools.

The combined fluid properties of water over a 10°C to 100°C temperature range. is given by the following function:

$$0.53 * \pi / 4 * k_t * [\ g \ b \ Pr \ / \ V^2 \ ] \ ** \ 0.25 \qquad (17)$$

The 0.53 comes from the original heat transfer correlation; the 4 is a product of the integral; k_t is the thermal conductivity in W/m.°C; g is gravity acceleration 9.81 m/s^2; b is the isobaric compressibility in 1/°C; Pr is the Prandlt number and v^2 is the square of the kinematic viscosity in m^4/s^2. All fluid property values are for water.

$$ZZ1 = DIA^{**}0.75*(1.2*TS1+63)*LE \quad (18a)$$

$$T_{out} = TS1 + Z*[\ ZZ1/MCP + ABS)T_{in}-TS1)^{**}-.25\ ]^{**}-4 \quad (18b)$$

$$dT_{out}/dT_{in}=[ABS(T_{out}-T_{in})/ABS(T_{in}-TS1)]^{**}1.25 \quad (18c)$$

where T_{in} = inlet temperature to the heat exchanger (°C)
T_{out} = outlet temperature of the heat exchanger (°C)
ABS = the absolute value function
TS1 = preheat storage tank temperature (°C)
DIA = coil outside diameter (m)
LE = coil length (m)
MCP = coil heat capacity flow rate (W/°C)
ZZ1 = temporary variable
Z = sign that allows a bi-directional equation
IF(TS1 > T_{in}) Z=-1 ELSE Z=1

The "(1.2*TS1+63)" factor is derived from a least squares curve fit to equation (17).

Wrap-Around:

The same integration used in the immersed-coil derivation (ref. 2) was made for the wrap-around case. The major difference is the power of the convection temperature difference, the equations are basically identical to those for the immersed-coil.

The combined fluid properties of water over a 10°C to 100°C temperature range is given in the following function for the immersed coil case:

$$0.13 / 3 * k_t * [\ g\ b\ Pr / v^2\ ]\ **\ 0.33 \quad (19)$$

The 0.13 comes from the original heat transfer correlation; the 3 is a product of the integral; k is the thermal conductivity in W/m.°C; g is gravity acceleration 9.81 m/s^2; b is the isobaric compressibility in 1/°C; Pr is the Prandlt number and v^2 is the square of the kinematic viscosity in m^4/s^2. All fluid properties are for water.

$$ZZ2 = AW*(1.23*TS1+38.3) \quad (20a)$$

$$T_{out} = TS1 + Z*[\ ZZ2/MCP + ABS(T_{in}-TS1)^{**}-.33\ ]^{**}-3 \quad (20b)$$

$$dT_{out}/dT_{in}=[ABS(T_{out}-T_{in})/ABS(T_{in}-TS1)]^{**}1.33 \quad (20c)$$

where T_{in} = inlet temperature to the heat exchanger (°C)
T_{out} = outlet temperature of the heat exchanger (°C)
ABS = the absolute value function
TS1 = preheat storage tank temperature (°C)
AW = wrap-around HX area (m^2)
MCP = coil heat capacity flow rate (W/°C)
ZZ2 = temporary variable
Z = sign that allows a bi-directional equation
IF(TS1 > T_{in}) Z=-1 ELSE Z=1

The "(1.23*TS1+38.3)" factor is derived from a least squares curve fit to equation (19).

2.5 The System Controller Model

Several adjustements have been made in NONLIN to control the solar system.

First, two differential temperature inputs are supported: DTON, and DTOFF for the on and off set points respectively. Other programs support the DTON and assumes DTOFF is the same.

Every hour, the collector plate stagnation temperature, referred to as TSTAG, is computed when solving for TCI in Equation 9 (with QC set to zero). Qc is described by a quadratic equation, and the root is found as follows:

Case I: The D coefficient is zero, therefore, the solution of the quadratic equation using the usual methods becomes undefined (division by 0). In this case, the equation for TSTAG is different.

For D = 0:

$$\Delta T = A*K*(I-E)/[C-B*K*(I-E)] \quad (°C) \qquad (21a)$$

$$TSTAG = \Delta T + Ta \qquad (21b)$$

Case II: For D <> 0:

$$ZZ3 = B*K*(I-E) - C \qquad (22a)$$

$$\Delta T = ZZ3 + \sqrt{[ZZ3*ZZ3 + 4*A*D*K(I-E)]}\ /(2*D) \qquad (22b)$$

$$TSTAG = \Delta T + Ta \qquad (22c)$$

where ΔT = stagnation to ambient temp. difference (°C)
I = incident solar radiation (W/m^2)
K = incident angle modifier
Ta = ambient temperature (°C)
TSTAG = collector stagnation temperature (°C)
ZZ3 = temporary variable
A, B, C, D, E = collector coefficients

If the expression within the square root sign in the evaluation of TSTAG is less then zero (i.e., complex roots), NONLIN will print out a message to the terminal of the condition and assume TSTAG is high enough to turn the system on. Note that if the system should have been not turned on, DTOFF will force it to turn off again.

At the beginning of the hour if (TSTAG-TS1) is greater than DTON, the system is assumed to turn on. The iteration loop is then run to determine the loop temperatures.

After the iteration is complete, the program compares the difference between TCO and TS1 (i.e., TCO-TS1) with the off differential. If the difference is greater than DTOFF, the system is allowed to stay on and collect energy. If the difference is less than DTOFF the system is shut down and the collected energy set to 0.

With this method, the energy collected becomes sensitive to TCO and hence DTOFF since the heat removal rate of the fluid flow directly determines TCO.

If the flow rate is low, and the DTOFF value is higher (say 10°C), at least a 10°C rise must appear across the collector array to ensure the system will be on for the hour.

2.6 Pipe Losses

Pipe losses are accounted for in NONLIN by the direct calculation of the inlet and outlet heat loss as the iteration is being performed. Both losses are assumed linear with temperature difference. The surface areas of the collector supply and return pipes and the heat loss coefficient should be specified by the user as UA.

The inlet pipe heat loss is given by:

QP = UAI * (TI - Ta) (W) (23)

where QP = inlet pipe heat loss in (W)
UAI = inlet pipe heat loss factor (W/°C)
TI = pipe inlet temperature (°C)
Ta = ambient temperature (°C)

The outlet pipe heat loss is given by:

QP = UAO * (TCO - Ta) (W) (24)

where QP = outlet pipe heat loss in (W)
UAO = outlet pipe heat loss factor (W/°C)
TCO = collector outlet temperature (°C)
Ta = ambient temperature (°C)

The pipe losses are subtracted from QC as computed by Equation 9.

3.0 USE OF THE NONLIN PROGRAM

The NONLIN program is virtually identical in operation to other hourly interactive programs. Some small differences in file handling and computer specific input/output are present.

3.1 The Interactive Front End

The interactive front end is called INTNOL and serves to create the "NONLIN" files.

Many of the subroutines present in hourly interactive programs were copied during the preparation of INTNOL, some changes were required to the program operation.

INTNOL is entirely menu-driven, and quite similar to other interactive programs as far as the user is concerned. The INTNOL program is entirely written in FORTRAN, and is run separately to create and modify NONLIN input files.

The collector data block now contains a 5 element vector to specify the collector coefficients instead of the $F_r\tau\alpha$ and F_rU_L lines used in linear model. An off differential set point is also included.

The operation of the program is self explanatory, a sample run is given in the tutorial section. One point regarding the adjustment of vectors with the INTNOL program is worth noting. When a vector is to be changed, enter the number of the item, similar to the method used to change a non-vector item. Rather than following the item number with the new value (a vector has more than one value), follow it with any number. Two numbers are sought before the program proceeds to process the request. After the two numbers have been entered, INTNOL will respond with a prompt asking the user if ONE, ALL or NONE of the vector elements are to be changed.

INTNOL supports all modules contained in the NONLIN program (e.g., DHWA, DHW2, etc.). The highest menu level allows the following commands:

1. CREATE. (Creates a new input file).
2. MODIFY. (Allows file modifications).
3. SAVE. (Allows the file to be saved).
4. PRINT. (Sends a file to the printer).
5. QUIT. (Halts execution).

The MODIFY command will prompt the user as to whether a disk file or the file in memory is to be modified. When all changes to the various data blocks have been made, make sure the file is saved to disk using the SAVE command.

The SAVE command requires the user to input a disk file name to save the data in. This name can be any valid operating system file name (an overwrite will automatically occur if the file already exits on disk).

3.2 Running NONLIN

Once the system specific data files have been created with the NONLIN program, NONLIN may be run.

The first prompt will ask the user the file name of the system data requested. Any valid file name (that was previously created and saved with INTNOL) can be specified. The program will then read the data file, and reflect the input data on the terminal or line printer.

The title page printout routine has been modified to make sure the program output is not assumed to be from the official WATSUN program.

The name of the system file containing the weather data is requested next. If a pre-tilted file was specified in the SIMU data block, enter the file name containing the pre-processed data. If horizontal input data was specified, enter the name of the file containing the horizontal weather data, and to the next prompt enter a suitable name for a file which will contain the pre-processed data generated from this run. This pre-processed weather data will be permanently saved in the disk file specified.

At the end of computer runs in a session, the user is advised to PURGE the weather data files created and stored on disc for both horizontal and tilted surface (processed weather data).

The purge command is:

PURGE, file name previously created, other file name previously created

4. TUTORIAL SESSION

4.1 Program Structure

4.1.1 Access to "INTNOL"

This procedure allows, in an interactive mode, the creation and modification of input data sets to a Data File. This interactive portion is the "INTNOL" procedure.

The command used is

```
GET, INTNOL/UN = DP834CC
BEGIN ,, INTNOL
```

4.1.2 The Data File

After creating or modifying a data file, the file is saved under a given name. The sample run used has a file named "TOWER".

4.1.3 Weather Tape "WWSAVE"

This procedure allows access to master weather data tape which contains weather data of 18 cities listed in table 1. A copy of the data of the called location is copied in the users catalog.

The command used is

```
GET, WWSAVE/UN = DP834CC
BEGIN,, WWSAVE, WEATHER = city name
```

4.2 Execution Program "NONLIN"

When the steps in 4.1 are completed, program runs can be made by using the following commands:

```
GET, NONLIN/UN = DP834CC
BEGIN,, NONLIN.
```

This allows the interactive execution of the "NONLIN".

It is important to emphasize that the "NONLIN" program calls the following files:

1 - a system data file
2 - a weather data file

which should be both readily available in the user's catalog.

4.3 The Sample Run

The steps in 4.1 and 4.2 are followed herein.

4.3.1 The Program commands:

```
          BEGIN..INTNOL


 WELCOME TO INTNOL   THE INTERACTIVE FRONT END FOR WATSUN.


 COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.


>ENTER FIRST LETTER :
? M
 READING DATA FILE  : DEFAULT


>MODIFY A DISK FILE (D) OR MEMORY FILE (M) ?
? D


>ENTER DISK FILE NAME (UP TO 7 CHARACTERS) :
? TOWER
```

4.3.2 The Create command:

```
BEGIN.,INTNOL


WELCOME TO INTNOL - THE INTERACTIVE FRONT END FOR WATSUN.


COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.

$ENTER FIRST LETTER :
? CREATE
 READING DATA FILE  : DEFAULT


 SELECT SYSTEM TYPE :

     DHW  DOMESTIC HOT WATER SYSTEM WITH PREHEAT STORAGE
     DHWO DOMESTIC HOT WATER SYSTEM WITHOUT STORAGE
     DHWA DOMESTIC HOT WATER SYSTEM WITH STORAGE AND EXCHANGERS
     L    LIQUID BASED SOLAR HEATING SYSTEM
     A    AIR BASED SOLAR HEATING SYSTEM
     LHPP LIQUID BASED SAHP SYSTEM WITH HP IN PARALLEL
     AHPP AIR BASED SAHP SYSTEM WITH HP IN PARALLEL
     LHPS LIQUID BASED SAHP SYSTEM WITH HP IN SERIES
     AHPS AIR BASED SAHP SYSTEM WITH HP IN SERIES
     LHPD LIQUID BASED SAHP SYSTEM W/ DUAL SOURCE HP
     AHPD AIR BASED SAHP SYSTEM W/ DUAL SOURCE HP
     LHPT LIQUID BASED SAHP SYSTEM WITH TWO STORAGES
     HP   AIR-TO-AIR HEAT PUMP
     ER   ELECTRIC RESISTANCE HEATING SYSTEM
     POOL SWIMMING POOL HEATING SYSTEM (INDOOR ONLY)

$ENTER SYSTEM NAME OR QUIT (QUIT) :
? DHWA

 ENTER THE TITLE OF THIS SIMULATION (MAX ONE LINE):

? TUTORIAL
```

4.3.3 The Modify command:

```
READY.
BEGIN,,INTNOL


 WELCOME TO INTNOL - THE INTERACTIVE FRONT END FOR WATSUN.


 COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.


$ENTER FIRST LETTER :
? M
 READING DATA FILE  : DEFAULT


$MODIFY A DISK FILE (D) OR MEMORY FILE (M) ?
? D


$ENTER DISK FILE NAME (UP TO 7 CHARACTERS) :
? TOWER
 READING DATA FILE  : TOWER


 THE TITLE IS:
 CN TOWER
$DO YOU WISH TO CHANGE THE TITLE (Y/N) ?
? N
```

4.3.3 The Modify command: (Cont'd)

```
 READING DATA FILE  : TOWER


 THE TITLE IS;
 CN TOWER
$DO YOU WISH TO CHANGE THE TITLE (Y/N) ?
? N



 SIMULATION
 COLLECTOR
 TANK DATA
 DHWLOAD
 EXCHANGER
 PIPE DATA
 ECONOMIC

 ENTER NAME OF BLOCK YOU WISH TO MODIFY (FIRST 4  LETTERS).
 OR ENTER QUIT :
? PIPE

 *PIPE DATA
 ITEM   DESCRIPTION                                              VALUE
 ----   -----------                                              -----
   1      PIPE AREA ON INLET SIDE OF COLLECTOR.....M2             32.0000
   2      PIPE AREA ON OUTLET SIDE OF COLLECTOR....M2             32.0000
   3      PIPE HEAT LOSS COEFFICIENT.....W/M2-C                   .130000

 ENTER ITEM NUMBER AND NEW VALUE OR ENTER QUIT (Q):
? Q



 SIMULATION
 COLLECTOR
 TANK DATA
 DHWLOAD
 EXCHANGER
 PIPE DATA
 ECONOMIC

 ENTER NAME OF BLOCK YOU WISH TO MODIFY (FIRST 4  LETTERS).
 OR ENTER QUIT :
? QUIT


 COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.


$ENTER FIRST LETTER :
? QUIT
```

4.3.4 The weather data file is called for as follows:

```
GET,WWSAVE/UN=DPS34CC
READY.
BEGIN,,WWSAVE,WEATHER=OTTAWA

  FILE =OTTAWA= WILL BE LOADED FROM TAPE
  THIS WILL TAKE A FEW MINUTES



  FILE =OTTAWA= HAS BEEN STORED IN YOUR CATALOG
  AT A DAILY STORAGE COST OF APPROXIMATELY $1.00 PER DAY
  REMEMBER TO PURGE IT WHEN NO LONGER REQUIRED


READY.
```

4.3.5 The execution of the program starts with the following commands, the program answer back calling for the system data file.

```
GET, NONLIN/UN=DP834CC
READY.
BEGIN.,NONLIN

 ENTER DISK FILE NAME CONTAINING SYSTEM DATA:
? TOWER
```

4.3.6 Program Run

```
                    DEVELOPED BY:

                        THE SYSTEMS DESIGN ENERGY GROUP
                        DEPARTMENT OF SYSTEMS DESIGN ENGINEERING

                        THE THERMAL ENGINEERING GROUP
                        DEPARTMENT OF MECHANICAL ENGINEERING


                          MODIFIED 20 FEB 84 FOR PDP-11/23 OPERATION
                          BY: SHEAFF AND ASSOCIATES ENGINEERING INC.
                              P.O. BOX 1048, MANOTICK, ONTARIO.

                          MODIFIED AUGUST 1984 TO ACCOMODATE A NON-LINEAR
                          COLLECTOR MODEL: BY SHEAFF AND ASSOCIATES
                          ENGINEERING INC., UNDER CONTRACT TO THE SOLAR
                          PROGRAMS OFFICE OF PUBLIC WORKS CANADA.

CN TOWER


                        ***  DATA INPUT LISTING  ***

    * GENERAL SYSTEM DATA
      -------------------

        + SIMULATION BEGINS IN YEAR.....................  1970
        + SIMULATION PERIOD (DAYS)......................   365
        + DAY1 OF THE PERIOD (1-365)....................     1
        + DETAILED PRINT-OUT (NO=0,YES=I-HR INTERVAL)      0
        + STARTING HOUR OF PRINT INTERVAL (0,...,I)...     0
        + DETAILED ANALYSIS PERIOD - START DAY .......     0
                                     END DAY .......     0
        + DATA SOURCE(1-WEATHER TAPE,2=PROCESSED TAPE)     1
        + SYSTEM TYPE (1 TO 1) .........................   3
        + ECONOMIC ANALYSIS (NO=0,YES=1)................   0
```

4.3.6 Program Run (Cont'd)

```
* COLLECTOR DATA
  -------------

    + STARTING AREA (M2)..........................  33.00
    + MAXIMUM AREA  (M2)..........................   0.00
    + INCREMENTAL AREA (M2).......................   0.00
    + MAXIMUM OUTLET TEMP.(C).....................    98.
    + CONTROLLER ON DIFFERENTIAL SETTING (C).....  10.00
    + CONTROLLER OFF DIFFERENTIAL SETTING (C)....   2.00
    + PUMP POWER / COLLECTOR AREA (W/M2).........    10.
    + FLOW RATE * HT.CAPACITY (W/M2-C)...........    50.
    + TILTED ANGLE OF COLLECTOR.(DEGREES)........  90.00
    + COLLECTOR ORIENTATION (SOUTH=0.,DEGREES)...   0.00
    + COLLECTOR PARAMETERS
        QC = (A + B*DT)*(I-E) - (C + D*DT) * DT, W/M2
                DT = TINLET - TAMBIENT, C
                A.................     .6800
                B.....:1/C:.......   -.0007
                C.....:W/M2.C:....   1.1200
                D.....:W/M2.C2:...    .0059
                E.....:W/M2:......  0.0000
    + INCIDENCE ANGLE MODIFIER VALUES.............
      FOR ANGLE       0.0      30.0      45.0      60.0      90.0
      AKT IS        1.000     1.000      .970      .877     0.000

* STORAGE TANK DATA
  ----------------

    + BASEMENT AIR TEMPERATURE (C)................  20.00
              FLOOR TEMPERATURE (C)................  18.00
    + PREHEAT STORAGE TANK
              VOLUME (M3)..........................    .60
              WALL AREA (M2).......................   3.50
              FLOOR AREA (M2)......................    .60
              HEAT LOSS COEFF (W/M2-C).............    .50
              DENSITY * HEAT CAP. (KJ/C-M3)........  4200.
              MAXIMUM TEMPERATURE (C)..............  98.00
              INITIAL TEMPERATURE (C)..............  20.00
    + AUXILIARY WATER HEATING TANK
              VOLUME (M3)..........................    .27
              WALL AREA (M2).......................   3.21
              FLOOR AREA (M2)......................    .29
              HEAT LOSS COEFF (W/M2-C).............    .80
              DENSITY * HEAT CAP. (KJ/C-M3)........  4200.
              MAXIMUM TEMPERATURE (C)..............  98.00
              INITIAL TEMPERATURE (C)..............  20.00
```

4.3.6 Program Run (Cont'd)

```
* DHW LOAD DATA
  -------------

     + WATER  MAIN  TEMPERATURES   MIN (C)..... 10.00
                                   MAX (C)..... 18.00
     + DESIRED HOT WATER TEMPERATURE   (C)..... 60.00
     + TOTAL DAILY LOAD FOR FIRST PART OF WEEK....  .650E+03
     + TOTAL DAILY LOAD FOR LAST  PART OF WEEK....  .275E+03
     + HOURLY HOT WATER SCHEDULE (LITRES)
     + FOR THE FIRST 7 DAYS OF THE WEEK
 .146E+02    0.          0.          0.          0.          0.
 .975E+01     .302E+02    .171E+02    .552E+02    .449E+02    .293E+02
 .234E+02     .332E+02    .176E+02    .156E+02    .137E+02    .244E+02
 .439E+02     .754E+02    .624E+02    .949E+02    .355E+02    .302E+02
     + FOR THE LAST  0 DAYS OF THE WEEK
0.           0.          0.          0.          0.          0.
0.           0.          0.          0.          0.          0.
0.           0.          0.          0.          0.          0.
0.           0.          0.          0.          0.          0.

* EXCHANGER DATA
  --------------

     + COLLECTOR/STORAGE EXCHANGER TYPE.....    1.0
       EXCHANGER PARAMETERS
            .650E+00  0.
     + STORAGE/LOAD EXCHANGER TYPE.....         1.0
       EXCHANGER PARAMETERS
            .100E+01  0.          0.

* PIPE DATA
  ---------

     + PIPE AREA ON INLET SIDE OF COLLECTOR (M2)..   32.0
                 OUTLET SIDE OF COLLECTOR (M2).      32.0
     + PIPE HEAT LOSS COEFFICIENT (W/M2 C).....      .130

* ECONOMIC DATA
  -------------

     + SYSTEM LIFE (YEARS).....                      20
     + TERM OF LOAN (YEARS).....                     20
     + INTEREST RATE OF LOAN.....                   .100
     + RATE OF RETURN (DISCOUNT RATE).....          .100
     + FIXED COST OF SOLAR COMPONENTS ($)..... 1000.
     + YEARLY MAINTENANCE COST OF SOLAR COMP.($/Y)   50.
     + SALVAGE VALUE AT END OF PERIOD ($).....       0.
     + UNIT COST OF COLLECTOR ($/M2).....          230.
     + UNIT COST OF STORAGE ($/M3).....            120.
     + UNIT COST OF FUEL AT PRESENT ($/GJ)..... 7.000
     + INFLATION RATE OF ENERGY
       0.000  13.000  13.000  10.000  10.000
      10.000  10.000   7.000   7.000   7.000
       7.000   7.000   7.000   7.000   7.000
       7.000   7.000   7.000   7.000   7.000
```

4.3.7 In the execution process the program calls for the weather data file and a name for the tilted data file.

```
ENTER THE FILE NAME FOR THE HORIZONTAL DATA.

? OTTAWA

ENTER THE FILE NAME FOR THE PROCESSED DATA.
  (UP TO 7 CHARACTERS)

? WOTT
```

4.3.8 Program Execution continues

* CITY DATA ON PROCESSED TAPE

+ CITY.....OTTAWA , ONT.
+ LATITUDE OF THE CITY (DEGREES)..... 45.45
+ COLLECTOR SLOPE (DEGREES)..... 90.00
+ COLLECTOR AZIMUTH (DEGREES)..... 0.00
+ WEATHER YEAR..... 1970

****
* ENERGY ANALYSIS SUMMARY *
****

EXPLANATION OF COLUMNS LISTED IN THE ENERGY ANALYSIS SUMMARY

1. HTOT TOTAL RADIATION
2. QCOL ENERGY COLLECTED
3. QDHW DEMAND FOR HOT WATER
4. QSHW ENERGY FROM STOR TO DHW
5. AUXW AUX ENERGY,WATER HEAT
6. AUXP AUX ENERGY,PUMPS/HEAT PUMPS
7. QTLS TOTAL LOSSES FROM TANKS
8. QPLS PIPE LOSSES

* COLLECTOR AREA : 33.00 M2 * STORAGE VOLUME : .60 M3

M	HTOT (GJ)	QCOL (GJ)	QDHW (GJ)	QSHW (GJ)	AUXW (GJ)	AUXP (GJ)	QTLS (GJ)	QPLS (GJ)
1	12.60	3.75	4.46	3.49	.97	.16	.52	.34
2	13.21	3.38	4.11	3.22	.88	.16	.48	.34
3	16.41	4.20	4.55	3.92	.65	.21	.57	.41
4	13.33	3.66	4.32	3.49	.81	.19	.53	.30
5	9.26	2.70	4.28	2.61	1.66	.18	.43	.15
6	9.33	2.85	3.97	2.70	1.27	.18	.44	.14
7	8.92	2.68	3.96	2.54	1.41	.18	.45	.13
8	11.45	3.61	3.89	3.30	.60	.20	.54	.22
9	9.55	2.95	3.77	2.85	.91	.15	.51	.18
10	10.32	2.99	3.99	2.82	1.18	.15	.53	.23
11	5.98	1.99	3.99	1.84	2.15	.08	.41	.12
12	9.30	3.07	4.30	2.86	1.45	.12	.48	.23
YR	129.68	37.84	49.60	35.66	13.95	1.96	5.88	2.79

4.3.8 Program Execution (Cont'd)

```
                                  ********************************
                                  *      EFFICIENCY  TABLE       *
                                  ********************************

EXPLANATION OF COLUMNS LISTED IN THE EFFICIENCY TABLE

COL. EFF.     COLLECTOR EFFICIENCY          (QCOL/HTOT)
STO. EFF.     STORAGE EFFICIENCY            (QSHW/QCOL)
SYS. EFF.     SYSTEM EFFICIENCY             (QSHW/HTOT)
COP           COEFFICIENT OF PERFORMANCE    (QSHW/AUXP)
SOLAR FRAC.   SOLAR FRACTION                ((QSHW-AUXP)/QDHW)


    * COLLECTOR AREA :  33.00 M2        * STORAGE VOLUME :     .60 M3
+--+--------+--------+--------+--------+--------+
| M | COL.   | STO.   | SYS.   | C.O.P. | SOLAR  |
|   | EFF.   | EFF.   | EFF.   |        | FRAC.  |
|   | (%)    | (%)    | (%)    |        | (%)    |
+--+--------+--------+--------+--------+--------+
| 1 | 29.79  | 92.91  | 27.68  | 21.91  | 74.64  |
| 2 | 25.59  | 95.31  | 24.39  | 19.80  | 74.51  |
| 3 | 25.60  | 93.25  | 23.87  | 18.52  | 81.35  |
| 4 | 27.48  | 95.36  | 26.21  | 18.62  | 76.55  |
| 5 | 29.12  | 96.90  | 28.21  | 14.86  | 56.97  |
| 6 | 30.53  | 94.85  | 28.96  | 14.87  | 63.45  |
| 7 | 30.05  | 94.86  | 28.51  | 14.47  | 59.84  |
| 8 | 31.54  | 91.44  | 28.84  | 16.25  | 79.70  |
| 9 | 30.85  | 96.59  | 29.80  | 18.72  | 71.48  |
|10 | 28.99  | 94.15  | 27.30  | 18.68  | 66.77  |
|11 | 33.25  | 92.72  | 30.83  | 23.17  | 44.21  |
|12 | 33.07  | 93.17  | 30.81  | 23.19  | 63.71  |
+--+--------+--------+--------+--------+--------+
|YR | 29.18  | 94.22  | 27.50  | 18.16  | 67.93  |
+--+--------+--------+--------+--------+--------+

        MAX. ENERGY COLLECTED PER BIN (MJ)    .173E+05

DT/I    QCOLL    0          .2          .4          .6          .8          1.
                 +----------+-----------+-----------+-----------+-----------+
0.00    .557E+03!*
                 !*
 .01    .884E+04!*************************
                 !*************************
 .02    .173E+05!*************************************************************
                 !*************************************************************
 .03    .103E+05!*********************************
                 !*********************************
 .04    .256E+04!*******
                 !*******
 .05    .718E+03!**
                 !**
 .06    .568E+02!*
                 !*

THIS RUN HAS STORED THE PROCESSED DATA ON
A PERMANENT FILE AT A COST OF ABOUT $3.60. PER DAY.
TO PURGE THIS FILE   ENTER:  PURGE,FILENAME
```

4.3.9 The Purge command:

```
PURGE.OTTAWA,WOTT
READY.
```

4.3.10 The Print command allows the data file to be copied and printed as follows. It does not allow results to appear in the printout.

```
SIMULATION
COLLECTOR
TANK DATA
DHWLOAD
CXCHANGER
PIPE DATA
ECONOMIC

ENTER NAME OF BLOCK YOU WISH TO MODIFY (FIRST 4  LETTERS).
OR ENTER QUIT :
? QUIT


 COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.


#ENTER FIRST LETTER :
? P


 COMMANDS

   CREATE : CREATES A NEW WATSUN INPUT FILE.
   MODIFY : TO MODIFY AN EXISTING WATSUN INPUT FILE.
   PRINT  : PRINTS A HARD COPY OF THIS WATSUN INPUT FILE.
   SAVE   : TO SAVE THE FILE IN MEMORY ON DISK.
   QUIT   : TO HALT EXECUTION.


#ENTER FIRST LETTER :
? QUIT

 THIS RUN HAS PRODUCED A PRINTER FILE
 ON LOCAL FILE: PRINT


READY.
```

4.3.10 The Print command (Cont'd)

```
LIST,F=PRINT

 84/09/28. 09.45.24.
PROGRAM   PRINT


$TITLE : CN TOWER



*SIMULATION
    1          SIMULATION YEAR.....................................YEAR          1970.00
    2          SIMULATION PERIOD...................................DAYS          365.000
    3          START DAY NUMBER (JAN 1=1, FEB 1 = 32, ETC.)..DAY                1.00000
    4          DETAILED PRINT INTERVAL (NO=0, 1=HOUR,ETC)....HR              0.
    5          STARTING HOUR OF DETAILED PRINT (NO=0, 1-24)..HR              0.
    6          DETAILED ANALYSIS PERIOD - START DAY..........DAY             0.
    7                                   - END DAY............DAY             0.
    8          WEATHER DATA TYPE (1=HORIZONTAL,2=TILTED).....                   1.00000
    9          SYSTEM NUMBER (1 THROUGH 15)..................                   3.00000
   10          ECONOMIC ANALYSIS REQUIRED (NO=0, YES=1)......                0.
*COLLECTOR
    1          STARTING AREA.....................................M2               33.0000
    2          MAXIMUM AREA......................................M2            0.
    3          INCREMENTAL AREA..................................M2            0.
    4          MAXIMUM COLLECTOR OUTLET TEMPERATURE..........C                   98.0000
    5          ON DIFFERENTIAL TEMPERATURE FOR CONTROL.......C                   10.0000
    6          PUMP POWER IN COLLECTOR LOOP PER UNIT AREA....W/M2                10.0000
    7          CAPACITANCE FLOW RATE PER UNIT AREA...........W/M2-C              50.0000
    8          OFF DIFFERENTIAL TEMPERATURE FOR CONTROL......C                   2.00000
    9          COLL COEF QC=(A+B*DT)(I-E)-(C+D*DT)*DT W/M2...:A..E:          0.
  #:  1      2      3      4      5
       .7    -.0    1.1     .0    0.0
   10          COLLECTOR SLOPE IN DEGREES.....................DEG.              90.0000
   11          COLLECTOR AZIMUTH (0=SOUTH,1=EAST) IN DEG.....DEG.            0.
   12          INCIDENCE ANGLE MODIFIER.......ANGLE VALUES...                0.
  #:  1      2      3      4      5
      0.0   30.0   45.0   60.0   90.0
   13          INCIDENCE ANGLE MODIFIER.........AKT VALUES...                0.
  #:  1      2      3      4      5
      1.0    1.0    1.0    .9     0.0
*TANK DATA
    1          PREHEAT TANK VOLUME.............................M3               .600000
    2            WALL AREA INCLUDING THE TOP...................M2               3.50000
    3            FLOOR AREA....................................M2               .600000
    4            HEAT LOSS FACTOR..............................W/M2-C           .500000
    5            DENSITY * HEAT CAPACITY OF FLUID.............KJ/M3-C           4200.00
    6          AUXILIARY TANK VOLUME...........................M3               .270000
    7            WALL AREA INCLUDING THE TOP...................M2               3.21000
    8            FLOOR AREA....................................M2               .290000
    9            HEAT LOSS FACTOR..............................W/M2-C           .800000
   10            DENSITY * HEAT CAPACITY OF FLUID.............KJ/M3-C           4200.00
   11          BASEMENT TEMPERATURE............................C                20.0000
   12          BASEMENT FLOOR TEMPERATURE......................C                18.0000
   13          STARTING PREHEAT TANK TEMPERATURE..............C                20.0000
   14          MAXIMUM TEMPERATURE IN PREHEAT TANK............C                98.0000
   15          MAXIMUM TEMPERATURE IN AUXILIARY TANK..........C                98.0000
```

4.3.10 The Print command (Cont'd)

```
*DHWLOAD
    1          MINIMUM MAINS WATER TEMPERATURE.............C              10.0000
    2          MAXIMUM MAINS WATER TEMPERATURE.............C              18.0000
    3          DESIRED HOT WATER SET TEMPERATURE...........C              60.0000
    4          TYPE OF LOAD (0= ENERGY, 1= VOLUMETRIC).....              1.00000
    5          NUMBER OF DAYS IN "WEEK-DAYS"  (MAX. 7).....              7.00000
    6          TOTAL DAILY LOAD FOR "WEEK-DAYS"  (KJ OR L).../DAY        650.000
    7          TOTAL DAILY LOAD FOR "WEEK-END"   (KJ OR L).../DAY        275.000
    8          HOURLY LOAD SCHEDULE FOR "WEEK-DAYS" (KJ OR L)PERCENT     100.000
  #:  1     2     3     4     5     6     7     8     9    10    11    12
      2.3   0.0   0.0   0.0   0.0   0.0   1.5   4.7   7.3   8.5   6.9   4.5
  #: 13    14    15    16    17    18    19    20    21    22    23    24
      3.6   5.1   2.7   2.4   2.1   3.8   6.8  11.6   9.6   6.9   5.5   4.7
    9          HOURLY LOAD SCHEDULE FOR "WEEK-END" (KJ OR L) PERCENT     0.
  #:  1     2     3     4     5     6     7     8     9    10    11    12
      0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
  #: 13    14    15    16    17    18    19    20    21    22    23    24
      0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
*EXCHANGER
    1          COLL-STOR EXCH. TYPE (1=EXT,2=WRAP,3=COIL)....            1.00000
    2          EXCHANGER PARAMETER 1.......................              .650000
    3          EXCHANGER PARAMETER 2.......................              0.
    4          STOR-LOAD EXCH. TYPE (1=EX,2=WRP,3=COIL,4=TNK)            1.00000
    5          EXCHANGER PARAMETER 1.......................              1.00000
    6          EXCHANGER PARAMETER 2.......................              0.
    7          CAPACITANCE FLOW RATE.....................KJ/HR-C        0.
*PIPE DATA
    1          PIPE AREA ON INLET SIDE OF COLLECTOR.......M2              32.0000
    2          PIPE AREA ON OUTLET SIDE OF COLLECTOR......M2              32.0000
    3          PIPE HEAT LOSS COEFFICIENT.................W/M2-C           .130000
*ECONOMIC
    1          SYSTEM LIFE IN YEARS.......................YEAR            20.0000
    2          TERM OF LOAN IN YEARS......................YEAR            20.0000
    3          INTEREST RATE ON LOAN AS A FRACTION........DECIMAL         .100000
    4          RATE OF RETURN (DISCOUNT RATE) AS A FRACTION..DECIMAL      .100000
    5          COST OF COLLECTOR PER UNIT AREA............$/M2            230.000
    6          COST OF STORAGE PER UNIT VOLUME............$/M3            120.000
    7          COST OF AUXILIARY ENERGY PER GJ............$/GJ             7.00000
    8          SALVAGE VALUE AT THE END OF SYSTEM LIFE.....$              0.
    9          OTHER FIXED COSTS...........................$              1000.00
   10          YEARLY MAINTENANCE COST.....................$/YEAR          50.0000
   11          YEARLY FUEL ESCALATION FOR LIFE............PERCENT         0.
  #:  1     2     3     4     5     6     7     8     9    10    11    12
      0.0  13.0  13.0  10.0  10.0  10.0  10.0   7.0   7.0   7.0   7.0   7.0
  #: 13    14    15    16    17    18    19    20
      7.0   7.0   7.0   7.0   7.0   7.0   7.0   7.0
READY.
```

5.0 SAMPLE NOMLIN DETAILED RUN INPUTS AND OUTPUTS

A sample run of the "Tower" system file is shown with detailed printout for a period of 5 days between 225 and 230.

```
CN TOWER


                    ***  DATA INPUT LISTING  ***

 * GENERAL SYSTEM DATA
 ---------------------

   + SIMULATION BEGINS IN YEAR.....................  1970
   + SIMULATION PERIOD (DAYS)......................     5
   + DAY1 OF THE PERIOD (1-365)....................   225
   + DETAILED PRINT OUT (NO=0,YES=1-HR INTERVAL)...     1
   + STARTING HOUR OF PRINT INTERVAL (0,..,I)......     1
   + DETAILED ANALYSIS PERIOD - START DAY .........   225
                                END DAY .........   230
   + DATA SOURCE(1=WEATHER TAPE,2=PROCESSED TAPE)...    1
   + SYSTEM TYPE (1 TO 14) ........................     3
   + ECONOMIC ANALYSIS (NO=0,YES=1)................     0
```

5.0 SAMPLE HOBLIN DETAILED RUN

```
 ENTER THE FILE NAME FOR THE HORIZONTAL DATA.

? OTTAWA

 ENTER THE FILE NAME FOR THE PROCESSED DATA.
  (UP TO 7 CHARACTERS)

? WOTT



     * CITY DATA ON PROCESSED TAPE
       ---------------------------

          + CITY.............................OTTAWA      . ONT.
          + LATITUDE OF THE CITY (DEGREES)..... 45.45
          + COLLECTOR SLOPE (DEGREES).......... 90.00
          + COLLECTOR AZIMUTH (DEGREES)..........  0.00
          + WEATHER YEAR.....................    1970

EXPLANATION OF COLUMNS IN THE DETAILED ENERGY ANALYSIS SUMMARY
 DAY   DAY NUMBER
 HR    HOUR OF THE DAY
 TA    AMBIENT TEMPERATURE (C)
 TC    COLLECTOR PLATE STAGNATION TEMPERATURE (C)
 TS    STORAGE TEMPERATURE (C)
 HT    RADIATION/AREA OF COLLECTOR (KJ/M2)
 QCOL  ENERGY COLLECTED (KJ)
 QDHT  DEMAND FOR SPACE HEAT (KJ)
 QDHW  DEMAND FOR HOT WATER  (KJ)
 QSHT  ENERGY TO SPACE HEATING FROM STORAGE (KJ)
 QSHW  ENERGY TO DHW PREHEATING FROM STORAGE (KJ)
 AUXH  AUXILIARY ENERGY FOR SPACE HEATING (KJ)
 AUXW  AUXILIARY ENERGY FOR HOT WATER HEATING (KJ)
 APHP  PURCHASED ENERGY FOR PUMPS/HEAT PUMPS (KJ)
```

5.0 SAMPLE HOSLIN DETAILED RUN (Cont'd)

*** DAY : 225 *** COLLECTOR AREA : 33.00 M2 *** STORAGE VOLUME : .60 M3 ***

DAY	HR	TA (C)	TC (C)	TS (C)	HT (KJ/M2)	QCOL (KJ)	QDHT (KJ)	QDHW (KJ)	QSHT (KJ)	QSHW (KJ)	AUXH (KJ)	AUXW (KJ)	APHP (KJ)
225	1	21.0	21.0	19.9	0.	0.	0.	2585.	0.	133.6	0.	2856.	0.
225	2	20.0	20.0	19.9	0.	0.	0.	0.	0.	0.	0.	404.9	0.
225	3	20.0	20.0	19.9	0.	0.	0.	0.	0.	0.	0.	404.9	0.
225	4	19.0	19.0	19.9	0.	0.	0.	0.	0.	0.	0.	404.9	0.
225	5	18.0	18.0	19.9	0.	0.	0.	0.	0.	0.	0.	404.9	0.
225	6	17.0	17.0	19.9	0.	0.	0.	0.	0.	0.	0.	404.9	0.
225	7	18.0	18.0	19.9	0.	0.	0.	1723.	0.	86.72	0.	2041.	0.
225	8	19.0	57.6	19.8	631.9	0.	0.	5342.	0.	264.4	0.	5482.	0.
225	9	23.0	84.4	24.8	793.8	.1307E+05	0.	8329.	0.	391.4	0.	8342.	1188.
225	10	23.0	118.8	32.8	1227.	.2173E+05	0.	9753.	0.	1622.	0.	8536.	1188.
225	11	23.0	153.0	44.4	1777.	.3215E+05	0.	7927.	0.	2814.	0.	5517.	1186.
225	12	25.0	159.6	55.7	1810.	.3188E+05	0.	5169.	0.	3257.	0.	2317.	1188.
225	13	26.0	156.3	65.2	1721.	.2785E+05	0.	4136.	0.	3713.	0.	827.9	1188.
225	14	28.0	161.7	73.3	1857.	.2732E+05	0.	5859.	0.	6575.	0.	0.	1188.
225	15	29.0	137.7	78.1	1477.	.1668E+05	0.	3102.	0.	4050.	0.	0.	1188.
225	16	28.0	104.4	76.4	1065.	0.	0.	2757.	0.	3872.	0.	0.	0.
225	17	28.0	65.7	74.9	613.7	0.	0.	2412.	0.	3245.	0.	0.	0.
225	18	27.0	27.0	72.6	0.	0.	0.	4308.	0.	5604.	0.	0.	0.
225	19	26.0	26.0	68.6	0.	0.	0.	7754.	0.	9499.	0.	0.	0.
225	20	26.0	26.0	62.6	0.	0.	0.	.1333E+05	0.	.1477E+05	0.	0.	0.
225	21	24.0	24.0	58.3	0.	0.	0.	.1103E+05	0.	.1058E+05	0.	0.	0.
225	22	23.0	23.0	55.4	0.	0.	0.	7927.	0.	6987.	0.	0.	0.
225	23	23.0	23.0	53.2	0.	0.	0.	6272.	0.	5275.	0.	0.	0.
225	24	22.0	22.0	51.4	0.	0.	0.	5342.	0.	4352.	0.	0.	0.
225TOT		23.2	62.6	46.1	.1297E+05	.1707E+06	0.	.1150E+06	0.	.8709E+05	0.	.3794E+05	8316.

DAY	HR	TA (C)	TC (C)	TS (C)	HT (KJ/M2)	QCOL (KJ)	QDHT (KJ)	QDHW (KJ)	QSHT (KJ)	QSHW (KJ)	AUXH (KJ)	AUXW (KJ)	APHP (KJ)
226	1	21.0	21.0	50.5	0.	0.	0.	2584.	0.	2055.	0.	891.0	0.
226	2	20.0	20.0	50.4	0.	0.	0.	0.	0.	0.	0.	404.9	0.
226	3	19.0	19.0	50.3	0.	0.	0.	0.	0.	0.	0.	404.9	0.
226	4	19.0	19.0	50.2	0.	0.	0.	0.	0.	0.	0.	404.9	0.
226	5	19.0	19.0	50.1	0.	0.	0.	0.	0.	0.	0.	404.9	0.
226	6	18.0	18.0	50.0	0.	0.	0.	0.	0.	0.	0.	811.6	0.
226	7	19.0	19.0	49.4	0.	0.	0.	1722.	0.	1316.	0.	1743.	0.
226	8	19.0	57.3	47.8	617.8	0.	0.	5339.	0.	4001.	0.	2822.	1188.
226	9	22.0	100.2	50.0	1090.	.1185E+05	0.	8325.	0.	5908.	0.	2709.	1188.
226	10	24.0	137.2	55.9	1562.	.2247E+05	0.	9749.	0.	7444.	0.	1172.	1188.
226	11	25.0	160.6	64.7	1891.	.2959E+05	0.	7923.	0.	7155.	0.	0.	1188.
226	12	27.0	173.2	75.1	2058.	.3221E+05	0.	5167.	0.	5745.	0.	0.	1188.
226	13	28.0	174.2	84.5	2058.	.2978E+05	0.	4134.	0.	5593.	0.	0.	1188.
226	14	29.0	164.6	90.0	1891.	.2329E+05	0.	5856.	0.	9030.	0.	0.	1188.
226	15	29.0	140.5	93.1	1527.	.1329E+05	0.	3100.	0.	4897.	0.	0.	1188.
226	16	30.0	108.5	91.1	1096.	0.	0.	2756.	0.	4426.	0.	0.	0.
226	17	30.0	68.0	89.5	613.1	0.	0.	2411.	0.	3687.	0.	0.	0.
226	18	30.0	30.0	86.7	0.	0.	0.	4306.	0.	6338.	0.	0.	0.
226	19	29.0	29.0	82.3	0.	0.	0.	7751.	0.	.1067E+05	0.	0.	0.
226	20	27.0	27.0	75.6	0.	0.	0.	.1332E+05	0.	.1846E+05	0.	0.	0.
226	21	26.0	26.0	70.8	0.	0.	0.	.1102E+05	0.	.1168E+05	0.	0.	0.
226	22	24.0	24.0	67.6	0.	0.	0.	7923.	0.	7682.	0.	0.	0.
226	23	23.0	23.0	65.2	0.	0.	0.	6269.	0.	5784.	0.	0.	0.
226	24	23.0	23.0	63.1	0.	0.	0.	5339.	0.	4763.	0.	0.	0.
226TOT		24.2	66.7	66.8	.1441E+05	.1625E+06	0.	.1150E+06	0.	.1246E+06	0.	.1218E+05	8316.

5.0 SAMPLE HOML.IN DETAILED RUN (Cont'd)

*** DAY : 227 *** COLLECTOR AREA : 33.00 M2 *** STORAGE VOLUME : .60 M3 ***

DAY	HR	TA (C)	TC (C)	TS (C)	HT (KJ/M2)	QCOL (KJ)	QDHT (KJ)	QDHW (KJ)	QSHT (KJ)	QSHW (KJ)	AUXH (KJ)	AUXW (KJ)	AFHF (KJ)
227	1	22.0	22.0	62.1	0.	0.	0.	2582.	0.	2246.	0.	0.	0.
227	2	21.0	21.0	62.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	3	21.0	21.0	61.9	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	4	20.0	20.0	61.8	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	5	19.0	19.0	61.6	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	6	19.0	19.0	61.5	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	7	19.0	19.0	60.8	0.	0.	0.	1722.	0.	1528.	0.	0.	0.
227	8	21.0	58.7	58.8	598.0	0.	0.	5337.	0.	4715.	0.	0.	0.
227	9	23.0	98.3	59.4	1028.	8902.	0.	8321.	0.	7152.	0.	0.	1188.
227	10	26.0	134.3	63.4	1454.	.1915E+05	0.	9744.	0.	8758.	0.	0.	1188.
227	11	28.0	159.0	70.7	1784.	.2672E+05	0.	7919.	0.	8025.	0.	0.	1188.
227	12	29.0	155.9	77.5	1639.	.2363E+05	0.	5165.	0.	6111.	0.	0.	1188.
227	13	31.0	159.9	84.3	1680.	.2316E+05	0.	4132.	0.	5463.	0.	0.	1188.
227	14	31.0	158.1	89.0	1704.	.2072E+05	0.	5853.	0.	8480.	0.	0.	1188.
227	15	31.0	132.3	91.3	1318.	.1086E+05	0.	3099.	0.	4611.	0.	0.	1188.
227	16	32.0	102.4	89.4	938.3	0.	0.	2755.	0.	4149.	0.	0.	0.
227	17	31.0	62.9	87.8	490.0	0.	0.	2410.	0.	3481.	0.	0.	0.
227	18	31.0	31.0	85.2	0.	0.	0.	4304.	0.	6015.	0.	0.	0.
227	19	29.0	29.0	81.0	0.	0.	0.	7747.	0.	.1021E+05	0.	0.	0.
227	20	27.0	27.0	74.5	0.	0.	0.	.1331E+05	0.	.1590E+05	0.	0.	0.
227	21	26.0	26.0	69.8	0.	0.	0.	.1102E+05	0.	.1141E+05	0.	0.	0.
227	22	25.0	25.0	66.7	0.	0.	0.	7919.	0.	7539.	0.	0.	0.
227	23	24.0	24.0	64.3	0.	0.	0.	6267.	0.	5689.	0.	0.	0.
227	24	23.0	23.0	62.3	0.	0.	0.	5337.	0.	4692.	0.	0.	0.
227TOT		25.4	64.5	71.1	.1263E+05	.1331E+06	0.	.1149E+06	0.	.1262E+06	0.	0.	8316.

DAY	HR	TA (C)	TC (C)	TS (C)	HT (KJ/M2)	QCOL (KJ)	QDHT (KJ)	QDHW (KJ)	QSHT (KJ)	QSHW (KJ)	AUXH (KJ)	AUXW (KJ)	AFHF (KJ)
228	1	22.0	22.0	61.3	0.	0.	0.	2581.	0.	2215.	0.	0.	0.
228	2	22.0	22.0	61.2	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	3	21.0	21.0	61.1	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	4	21.0	21.0	60.9	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	5	20.0	20.0	60.8	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	6	19.0	19.0	60.7	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	7	21.0	21.0	60.0	0.	0.	0.	1721.	0.	1508.	0.	0.	0.
228	8	22.0	54.5	58.0	493.3	0.	0.	5335.	0.	4653.	0.	0.	0.
228	9	23.0	72.1	55.1	502.0	0.	0.	8318.	0.	7064.	0.	0.	0.
228	10	24.0	106.2	56.5	973.2	.1180E+05	0.	9740.	0.	7925.	0.	0.	1188.
228	11	26.0	129.2	60.8	1238.	.1814E+05	0.	7916.	0.	6993.	0.	0.	1188.
228	12	27.0	153.9	68.8	1634.	.2556E+05	0.	5163.	0.	5211.	0.	0.	1188.
228	13	29.0	146.7	74.9	1456.	.2080E+05	0.	4130.	0.	4978.	0.	0.	1188.
228	14	29.0	42.3	71.7	100.3	0.	0.	5851.	0.	7829.	0.	0.	0.
228	15	21.0	43.6	70.0	195.6	0.	0.	3098.	0.	3785.	0.	0.	0.
228	16	22.0	63.1	68.6	466.6	0.	0.	2753.	0.	3244.	0.	0.	0.
228	17	23.0	40.8	67.3	249.9	0.	0.	2409.	0.	2757.	0.	0.	0.
228	18	23.0	23.0	65.3	0.	0.	0.	4302.	0.	4810.	0.	0.	0.
228	19	24.0	24.0	61.9	0.	0.	0.	7740.	0.	8286.	0.	0.	0.
228	20	24.0	24.0	56.5	0.	0.	0.	.1331E+05	0.	.1318E+05	0.	0.	0.
228	21	21.0	21.0	52.6	0.	0.	0.	.1101E+05	0.	9688.	0.	0.	0.
228	22	21.0	21.0	49.9	0.	0.	0.	7916.	0.	6478.	0.	1535.	0.
228	23	20.0	20.0	47.9	0.	0.	0.	6264.	0.	4761.	0.	1908.	0.
228	24	19.0	19.0	46.3	0.	0.	0.	5335.	0.	3804.	0.	1935.	0.
228TOT		22.7	47.9	60.8	7391.	.7630E+05	0.	.1149E+06	0.	.1092E+06	0.	5398.	4752.

5.0 SAMPLE BOXLIN DETAILED RUN (Cont'd)

*** DAY : 229 *** COLLECTOR AREA : 33.00 M2 *** STORAGE VOLUME : .60 M3 ***

DAY	HR	TA (C)	TC (C)	TS (C)	HT (KJ/M2)	QCOL (KJ)	QDHT (KJ)	QDHW (KJ)	QSHT (KJ)	QSHW (KJ)	AUXH (KJ)	AUXW (KJ)	APHF (KJ)
229	1	19.0	19.0	45.6	0.	0.	0.	2580.	0.	1742.	0.	1243.	0.
229	2	17.0	17.0	45.5	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	3	18.0	18.0	45.4	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	4	16.0	16.0	45.3	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	5	16.0	16.0	45.3	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	6	15.0	15.0	45.2	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	7	16.0	16.0	44.7	0.	0.	0.	0.	0.	0.	0.	404.9	0.
229	8	17.0	58.4	43.2	654.1	0.	0.	1720.	0.	1115.	0.	1010.	0.
229	9	19.0	103.2	46.7	1182.	.1381E+05	0.	5333.	0.	3390.	0.	2348.	0.
229	10	20.0	92.0	47.9	806.6	.1004E+05	0.	8314.	0.	5005.	0.	3714.	1188.
229	11	21.0	159.2	58.1	1926.	.3156E+05	0.	9736.	0.	6654.	0.	3487.	1188.
229	12	21.0	117.4	61.8	1080.	.1452E+05	0.	7913.	0.	5645.	0.	2672.	1188.
229	13	22.0	100.0	64.3	916.1	.1085E+05	0.	5161.	0.	4932.	0.	633.3	1188.
229	14	21.0	134.6	69.0	1422.	.1852E+05	0.	4128.	0.	4308.	0.	225.5	1188.
229	15	23.0	84.0	67.3	646.2	0.	0.	5849.	0.	6446.	0.	0.	1188.
229	16	22.0	92.9	65.9	932.7	0.	0.	3096.	0.	3740.	0.	0.	0.
229	17	22.0	61.8	64.7	622.7	0.	0.	2752.	0.	3203.	0.	0.	0.
229	18	22.0	22.0	62.7	0.	0.	0.	2408.	0.	2720.	0.	0.	0.
229	19	21.0	21.0	59.3	0.	0.	0.	4300.	0.	4744.	0.	0.	0.
229	20	20.0	20.0	54.1	0.	0.	0.	7741.	0.	8166.	0.	0.	0.
229	21	19.0	19.0	50.2	0.	0.	0.	.1330E+05	0.	.1297E+05	0.	309.7	0.
229	22	17.0	17.0	47.7	0.	0.	0.	.1101E+05	0.	9457.	0.	1957.	0.
229	23	17.0	17.0	45.9	0.	0.	0.	7913.	0.	6073.	0.	2245.	0.
229	24	15.0	15.0	44.4	0.	0.	0.	6262.	0.	4434.	0.	2232.	0.
229TOT		19.0	52.5	52.9	.1019E+05	.9931E+05	0.	5333.	0.	3543.	0.	2194.	0.
								.1149E+06	0.	.9829E+05	0.	.2630E+05	7128.

5.0 SAMPLE HOMLIN DETAILED RUN (Cont'd)

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                    ******************************
                    *  ENERGY ANALYSIS SUMMARY   *
                    ******************************
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EXPLANATION OF COLUMNS LISTED IN THE ENERGY ANALYSIS SUMMARY

1. HTOT TOTAL RADIATION
2. QCOL ENERGY COLLECTED
3. QDHW DEMAND FOR HOT WATER
4. QSHW ENERGY FROM STOR TO DHW
5. AUXW AUX ENERGY,WATER HEAT
6. AUXP AUX ENERGY,PUMPS/HEAT PUMPS
7. QTLS TOTAL LOSSES FROM TANKS
8. QPLS PIPE LOSSES

* COLLECTOR AREA : 33.00 M2 * STORAGE VOLUME : .60 M3

M	HTOT (GJ)	QCOL (GJ)	QDHW (GJ)	QSHW (GJ)	AUXW (GJ)	AUXP (GJ)	QTLS (GJ)	QPLS (GJ)
8	1.90	.64	.63	.55	.08	.04	.09	.03
YR	1.90	.64	.63	.55	.08	.04	.09	.03

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                    ******************************
                    *     EFFICIENCY  TABLE      *
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EXPLANATION OF COLUMNS LISTED IN THE EFFICIENCY TABLE

COL. EFF.	COLLECTOR EFFICIENCY	(QCOL/HTOT)
STO. EFF.	STORAGE EFFICIENCY	(QSHW/QCOL)
SYS. EFF.	SYSTEM EFFICIENCY	(QSHW/HTOT)
COP	COEFFICIENT OF PERFORMANCE	(QSHW/AUXP)
SOLAR FRAC.	SOLAR FRACTION	((QSHW-AUXP)/QDHW)

5.0 SAMPLE HOMLIN DETAILED RUN (Cont'd)

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    * COLLECTOR AREA :  33.00 M2        * STORAGE VOLUME :     .60 M3
+---+---------+---------+---------+---------+---------+
  M   COL.      STO.      SYS.      C.O.P.    SOLAR
      EFF.      EFF.      EFF.                FRAC.
      (%)       (%)       (%)                 (%)
+---+---------+---------+---------+---------+---------+
  8   33.78     84.96     28.70     14.81     81.08
+---+---------+---------+---------+---------+---------+
 YR   33.78     84.96     28.70     14.81     81.08
+---+---------+---------+---------+---------+---------+

          MAX. ENERGY COLLECTED PER BIN (MJ)    .227E+03

DT/I    QCOLL    0         .2         .4         .6         .8         1.
                 +---------+----------+----------+----------+----------+
0.00    .634E+02!**************
                !**************
  .01   .168E+03!**************************************
                !**************************************
  .02   .227E+03!******************************************************
                !******************************************************
  .03   .115E+03!*************************
                !*************************
  .04   .314E+02!******
                !******
```

THIS RUN HAS STORED THE PROCESSED DATA ON
A PERMANENT FILE AT A COST OF ABOUT $3.60 PER DAY.
TO PURGE THIS FILE ENTER: PURGE,FILENAME

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READY.
PURGE,OTTAWA,WDTT
READY.
```

TABLE 1

LOCATION CODE	LOCATION	PROVINCE
VANC	Vancouver	B.C.
INUVIK	Inuvik	N.W.T.
CALGARY	Calgary	Alta
REGINA	Regina	Sask.
WINNIPE	Winnipeg	Man.
THUNDER	Thunder Bay	Ont.
SUDBURY	Sudbury	Ont.
KINGSTO	Kingston	Ont.
KENORA	Kenora	Ont.
LONDON	London	Ont.
TORONTO	Toronto	Ont.
OTTAWA	Ottawa	Ont.
MONTREA	Montreal	Quebec
QUEBEC	Quebec	Quebec
FREDERI	Fredericton	N.B.
SYDNEY	Sydney	N.S.
STJOHNS	St. John's	Nfld.
WHITEHO	Whitehorse	Yuk.

All locations are for 1970 weather data.

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7. WATSUN 6.0 Source Code Listing. Obtained from the WATSUN USER SERVICE, University of Waterloo, Waterloo, Ontario.

POOR

QUALITY

ORIGINAL